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## 7. AT GRADE INTERSECTIONS

The American Association of State Highway and Transportation Officials (AASHTO) *A Policy on the Geometric Design of Highways and Streets (Green Book)* defines an intersection as “the general area where two or more highways join or cross, including the roadway and roadside facilities for traffic movements within the area” (2004). In addition to this definition, GDOT considers driveways essentially to be low-volume intersections. GDOT Policies relating to driveways are discussed in greater detail in **Section 7.4.** of this Manual.

The main objective of intersection design should be to facilitate the safety, convenience, ease, and comfort of people traversing the intersection while enhancing the safe and efficient movement of motor vehicles, buses, trucks, bicycles, and pedestrians.

### 7.1. Intersection Design Elements

The efficiency, safety, operational costs, and capacity of the facility depend on proper intersection design. Intersection design should be fitted closely to the natural transition paths and operating characteristics of its users. The five basic elements that should be considered in intersection design are:

- **Human Factors** - driving habits, the ability of motorists to make decisions, driver expectations, decision and reaction time, conformance to natural paths of movement, pedestrian use and habits, bicycle use and habits.
- **Traffic Considerations** - design and actual capacities, design-hour turning movements, size and operating characteristics of vehicle, variety of movements (diverging, merging, weaving, and crossing), vehicle speeds, transit involvement, crash experience, bicycle movements, pedestrian movements.
- **Physical Elements** - character and use of abutting property, horizontal and vertical alignments at the intersection, sight distance, angle of the intersection, conflict area, speed-change lanes, geometric-design features, traffic control devices, lighting equipment, safety features, bicycle traffic, environmental factors, cross walks, parking, directional signing and marking.
- **Economic Factors** - cost of improvements, effects of controlling or limiting rights-of-way on abutting residential or commercial properties where channelization restricts or prohibits vehicular movements, energy consumption.
- **Functional Intersection Area** - boundary (much larger than the physical intersection; includes perception-reaction distance, maneuver distance, deceleration distance and queue-storage distance), access points.

AASHTO *Green Book* (2004)

## 7.2. Intersection Geometrics

The most common intersection of two highways has four legs. *GDOT discourages the design of intersections with more than four legs.*

Each intersection involves through- or cross-traffic movements on one or more of the highways and may involve turning movements between these highways. Such movements may be facilitated by various geometric design and traffic control, depending on the type of intersection.

### 7.2.1. Angle of Intersection/Skew Angle

Refer to **Chapter 4, Elements of Design, Section 4.1.5. Intersection Sight Distance**, of this manual for design policies concerning angle of intersection/skew angle.

### 7.2.2. Right-of-Way Flares

Refer to **Chapter 4, Elements of Design, Section 4.1.5. Intersection Sight Distance**, for design policies concerning right-of-way flares.

### 7.2.3. Turn Lanes

The length of a turn lane consists of three components: entering taper, deceleration length, and storage length. When practical, the total length of turn lane should be determined based on the design speed and the storage requirement for the turn lane and adjacent through-lane queue.

At a minimum, for design speeds < 45 mph, taper and deceleration lengths shall be designed in accordance with the GDOT Regulations for Driveway and Encroachment Control.

At a minimum, for design speeds  $\geq$  45 mph, taper and deceleration lengths shall be designed in accordance with Georgia Construction Detail M-3

For further design guidance relating to the design of turn lanes, refer to the AASHTO Green Book, Chapter 9, Auxiliary Lanes.

The following controls and requirements are established for placement of acceleration/ deceleration lanes on reconstruction projects for the new construction or reconstruction of divided multi-lane roadways with median widths greater than 12-ft.

#### Left Turn Lanes

For projects involving the new construction or reconstruction of a multi-lane, divided highway with a median width greater than 12-ft., left-turn lanes shall be placed at all median openings.

#### Right Turn Lanes

When the posted speed is greater than or equal to 45 mph on multi-lane divided highways, right turn deceleration lanes shall be placed at paved public street intersections and direct entrances to major traffic generators.

When the posted speed is less than 45 mph on multi-lane divided highways, right turn deceleration lanes shall be placed at paved public street intersections and major traffic generators under the following conditions:

- a. Mainline current traffic volumes exceed 10,000 vehicles per day, and

- b. Traffic volumes on the side road exceed 200 vehicles per day with peak hour right turn movements from the main road exceeding 20 vehicles per hour.

In addition, every effort should be made to replace existing right turn lanes at commercial driveways when practical. The benefits of including a turn lane may not always outweigh the impacts the turn lane will have on adjacent parcels. Sound engineering judgment should be used to determine if the benefits of replacing the right turn lane outweigh the impacts. Coordination with the Division of Preconstruction, the Office of Traffic Safety and Design, and District Access Management Engineer is recommended.

#### 7.2.4. Islands

An Island is defined as “the area between traffic lanes used for control of vehicle movement. Islands also provide for an area for pedestrian refuge and traffic control devices” (AASHTO, 2004). Islands may be raised or painted. Refer to **Chapter 6, Cross Section Elements** of this Manual for design policies concerning curb-face type and height for a specific roadway design speed.

“A refuge island for pedestrians is one at or near a crosswalk or bicycle path that aids and protects pedestrians and/or bicyclists who cross the roadway” (AASHTO 2004). Refuge islands should be considered in areas where the roadway is too wide to allow a pedestrian to cross the entire intersection in one movement. With respect to the geometric design of refuge islands:

- Refuge islands must be large enough to allow motorists to see the refuge area
- Refuge islands should not interfere with turning movements
- The addition of refuge islands generally requires larger intersection areas

#### 7.2.5. Intersection Radii

Turning radii treatments for intersections are important design elements that affect the operation, safety, and construction costs of the intersection. Several basic parameters should be considered in determining the appropriate corner and control radii and length of median opening including: intersection angle, number and width of lanes, design vehicle turning path, clearances, encroachment into oncoming or opposing lanes, parking lanes, shoulders, and pedestrian needs.

The *GDOT Driveway Manual* provides typical radii for various applications; however, these values are for typical situations and should not be used exclusively without sound engineering judgment and use of appropriate design tools (refer to **Chapter 3, Design Controls**, of this Manual).

### 7.3. Median Openings

For design policies concerning median cross sectional elements, refer to **Chapter 6. Cross Section Elements, Section 6.8. Medians**, of this Manual.

Medians separating opposite direction travel lanes shall be installed for the primary purpose of ensuring the safe, efficient movement of traffic. The introduction of median openings increases the driving hazard and also impedes the smooth flow of traffic, thus reducing the safety and capacity of highways.

The following guidelines shall be followed when allowing median crossovers, as well as when requests are received for additional crossovers on completed roadway sections:

- Median Crossovers should not typically be installed or permitted to serve a particular development; however, when it can be documented that such an installation will benefit the overall safety, traffic flow and efficiency of the roadway, consideration will be given to installing a median opening. Priority will be given to establishing crossovers at existing roads and streets before other locations.
- GDOT prefers full median openings to be spaced at 1,000-ft. in urban areas. However, median openings may be spaced less than 1,000-ft., and greater than 660-ft., in urban areas if there are minimal left turn volumes. Median openings shall be spaced at 1320-ft. in rural areas. For all other intersections spacings greater than the minimum specified median openings must be determined based on taper, deceleration, and storage lengths based on traffic volumes.
- The maximum spacing between median crossovers in developed areas (including single occupied residence) should be one mile. In areas without any development or where there are no driveways due to access control, the maximum spacing between crossovers should be 2 miles. In urban areas a practical maximum spacing between crossovers is approximately ½ mile. Since it is preferable to place crossovers only at local roads, the crossover may be shifted slightly to line up with an existing road or major traffic generator.
- Median crossovers for new and reconstructed facilities shall be constructed in accordance with GDOT *Construction Standards and Details*<sup>1</sup>, Construction Detail M-3, Type A, B, or C. Type B crossovers are preferred and should be used where drainage can be adequately designed and speeds are greater than or equal to 55 mph. Consideration for use of Type B crossovers should also be given when engineering judgment dictates that the design is practical in median widths less than 32-ft. and when there are more than two approach through lanes.
- For 6 lane roadways, full median breaks shall be granted only at signalized intersections.
- For four-lane, divided projects with less than 32-ft. of median width, additional pavement width (i.e., eyebrow) to facilitate U-turn movements shall be provided as part of the crossover construction. However, depending on traffic type using the facility additional pavement for U-turns shall be verified with appropriate turning paths, may require truck turn-around ramps (i.e., jug handles). Refer to the GDOT *Construction Standards and Details*, Construction Detail M-3, Type C Median Crossover.
- Deceleration lanes will be provided at all crossovers.
- Adequate sight distance shall be available for any location where crossover is allowed.
- The designer shall refer to the National Cooperative Highway Research Program (NCHRP) report, *Safety of U-Turns at Unsignalized Median Openings (Report 524)*, when designing intersections with U-turn capability.

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<sup>1</sup> GDOT. *Construction Standards and Details*. 2006

Note: Current Construction Standards and Details may be downloaded from:  
[http://tomcat2.dot.state.ga.us/stds\\_dtls/index.jsp](http://tomcat2.dot.state.ga.us/stds_dtls/index.jsp)

## 7.4. Driveways

GDOT considers driveways, or non-roadway access points to the State Route System, as essentially low-volume intersections that merit special consideration in their design and location.

The designer should be familiar with the policies and procedures described in the current version of GDOT's *Regulations for Driveway and Encroachment Control*<sup>2</sup> (*Driveway Manual*).

New driveways and modifications to existing driveways are regulated through the use of permits. Driveway permits (referred to as "access permits") are necessary in order to preserve the functional integrity of the State Highway System and to promote the safe and efficient movement of people and goods. Access permit regulations generally control right-of-way encroachment and driveway design, location, and number. Access approved for newly constructed commercial developments may, and in-fact often, stipulate parking requirements (for parking adjacent to state-owned rights of way) and setback distances to buildings and/or sign structures. When a roadway is widened, parking, setback distances, ingress/egress and parcel circulation may be impacted.

A consistent design approach must be applied to both existing driveways requiring reconstruction and proposed driveways for new developments. All reconstructed driveways should be compliant with the GDOT *Driveway Manual*. However, given the constraints of reconstructing an existing driveway, GDOT recognizes that it may not always be possible to reconstruct a driveway in strict accordance with the GDOT *Driveway Manual* and standards. When roadways are to be widened, the replacement driveway may not require the same access/egress features, such as a right turn deceleration lane and/or acceleration lane. The need for the replacement of these features shall be evaluated on a case by case basis. In some cases replacement of access features in kind may not be justified due to excessive impacts to adjacent parcels.

The safety and efficiency of the State Highway System are affected by the amount and character of intersecting streets and driveways. While it is recognized that property owners have certain right of access, the public also has the right to travel on the road system with relative safety and freedom from interference. It is GDOT's intent to balance the often conflicting interests of property owners and the traveling public.

## 7.5. Signalization

The designer should be familiar with the current version of the GDOT *TOPPS 6785-1*<sup>3</sup>, Traffic Signals. The information contained in this Section is intended to supplement the information contained in TOPPS 6785-1. The following provides some general guidelines for signalized intersection design:

<sup>2</sup> GDOT. *Regulations for Driveway and Encroachment Control*. 2006

The 2006 version of this publication is available online at:

<http://www.dot.ga.gov/doingbusiness/PoliciesManuals/roads/Pages/DesignPolicies.aspx>

Note: It is named "GDOT Driveway and Encroachment Control Manual" in the R-O-A-D-S Index.

<sup>3</sup> TOPPS 6785-1 is available on the GDOT Transportation Online Policies and Procedures System (TOPPS) at: <http://www.dot.ga.gov/doingbusiness/PoliciesManuals/Pages/topps.aspx>

- All signalized intersections shall be designed in accordance with the *GDOT Traffic Signal Design Guidelines*.
- Distance between stop bars on opposing movements should be set to minimum standards wherever possible, thus minimizing necessary clearance timings.
- The use of pedestrian refuge islands should be considered whenever possible to minimize pedestrian clearance times.
- The designer should communicate with the District Utilities Engineer to compile a list of all utilities which may be affected both underground and overhead. The location of utilities should be included on the signal plans so that they may be avoided. Special attention should be given to overhead utilities crossing the intersection to ensure that they do not conflict with the proposed signal span wire, mast arms, or signal heads, and that the design is able to meet National Electric Safety Code requirements.
- Actual (existing) and projected (design) volumes, including turn movements, should be collected and determined for the intersection.
- The designer should determine if the proposed signal will be part of a coordinated signal system, and if so, the development of communication plans or timing plans are needed.
- The designer should closely evaluate the sequence of construction and maintenance of traffic to determine if temporary signals are needed.
- Where possible signal poles / mast arms should be located to allow for use with both temporary signalization, and final signalization.
- The intersection controller cabinet shall be located where it can be utilized in the temporary signals, as well as the final signal design.
- Location of the PED button and PED signal, curb cut ramps, strain pole, controller cabinets, crosswalk and landing areas, should all be coordinated to ensure a fully accessible intersection. The designer should check the right of way to ensure that there is enough room to install these items.
- The intersection controller cabinet shall be located to avoid creating a sight distance obstruction in all phases of construction.
- Signal heads shall be designed with sufficient slack wiring to allow the heads to be relocated to different places on the span wire / mast arm for use in both the temporary and final signals.
- Wherever possible, loops, pullboxes, and loop lead-ins shall be placed to be used for both the temporary signals as well as the final signals.
- For signals mounted on mast arms, the designer should provide sufficient length on the arms to allow for both future signal heads, as well as field adjustments if needed.
- The designer should contact the maintaining agency that is responsible for the existing intersections in the area to determine design standards which may be unique to the area.

- As applicable, the construction of the signalized intersection should be carefully considered when developing maintenance of traffic plans.
- Consider decision sight distance as it relates to signal head and traffic control devices, and the queue length for the signal.
- When designing a roadway or roadway improvements, particular attention should be paid to the future operations at the project intersections. Where existing signalization does not exist, the intersection should be evaluated to determine if signalization is required as part of the project. If the project includes an existing signalized intersection, the intersection should be evaluated to determine if improvements are required as part of the project.

### **7.5.1. New Intersections and Existing Unsignalized intersections**

At existing non-signalized and new intersections which are a part of the project design, the designer should request the District Traffic Operations Engineer perform a Traffic Engineering Study (including a signal warrant analysis) to determine if signalization may be warranted. The results of the study, along with the recommendations shall be documented in a Traffic Engineering Report. The signal warrant analysis shall be performed in accordance with the current version of the FHWA *Manual on Uniform Traffic Control Devices (MUTCD)*<sup>4</sup>.

The Traffic Engineering Study should be performed under two separate scenarios:

- At locations where the intersections exist in the field, the intersection should be evaluated under existing volumes (as determined by field counts) and future lane configuration (based on the project design). If the intersection meets warrants under these conditions, the signal design should be included in the design package, and the signal should be installed as part of the project construction.
- At locations where an intersection exists in the field but does not meet warrants under existing traffic conditions, and at locations where the intersection does not exist in the field (new intersection as part of the design project) the intersection should be evaluated using design volumes (volumes developed as part of a traffic study) and future lane configuration (based on project design). Intersections that meet warrants under this scenario should be considered for inclusion in the design package. The designer should work closely with the District Traffic Operations Engineer to determine if signalization should occur as part of the project, or in a future stage.

In either case, the roadway / intersection should be designed to allow for future signalization. Necessary turn lanes should be provided, or space to develop future turn lanes should be planned. Right-of-way should be provided for future signal poles and intersection equipment.

### **7.5.2. Signal Modification**

New signal plans should be developed for all existing signalized intersections where roadway improvements are being made. The existing signalized intersection should be evaluated to

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<sup>4</sup> FHWA. Manual on Uniform Traffic Control Devices (MUTCD).

The 2003 version is available online at: Available online at: <http://mutcd.fhwa.dot.gov/kno-2003r1.htm>

determine its existing operation. The intersection should then be analyzed with both existing volumes and design volumes using the future lane configuration to determine the appropriate intersection phasing. If future phasing changes will be needed, design allowance should be incorporated to provide room for additional signal heads, loop detectors, and mast arm lengths. Any modification to existing signals requires a revision to the existing signal permit.

### 7.5.3. Geometric Design Elements

In rural areas, if there will be an auxiliary lane for acceleration after a right turn movement, it must provide adequate acceleration length to merge into traffic (as discussed in this Manual in **Chapter 4, Elements of Design, Section 4.2.5. Transition in Number of Lanes**). The lane must also be free of any driveways for the length of the auxiliary lane.

## 7.6. Roundabouts

A modern roundabout is a type of circulatory roadway in which all traffic flows counter-clockwise around a central island. The Georgia Department of Transportation (GDOT) recognizes that the roundabout is a viable intersection alternative when placed in the appropriate location, and designed properly for the local conditions. Research has shown that roundabouts are significantly safer than traffic signals in certain conditions and will eliminate the ongoing cost for maintaining the traffic signals. Roundabouts have also been proven to provide improved capacity and safety over all-way stops. The Chief Engineer has developed the guidance below for determining when the use of a roundabout is acceptable in Georgia..

- Roundabouts are the preferred safety and operational alternative for a wide range of intersections of public roads. A roundabout shall be considered as an alternative in the following instances: Any intersection in a project that is being designed as new or is being reconstructed.
- All existing intersections that have been identified as needing major safety or operational improvements.
- All signal requests at intersections (provide justification in the Traffic Engineering Study if a roundabout is not selected).

### 7.6.1. Georgia Roundabouts Selection Criteria

Roundabouts may not operate well if there is too much traffic entering the intersection or if the percentage of traffic on the major road is too high. Candidate intersections shall be analyzed to determine whether a roundabout will perform acceptably. Shown below are thresholds to determine if a roundabout capacity analysis is required:

# of Circulatory Lanes	ADTs (current/build year)	% traffic on Major Road
Single Lane	less than 20,000	less than 80%
Multi-Lane	less than 40,000	less than 80%

Other things to consider when evaluating roundabouts as an alternative are Right of Way, sight distance, environmental impacts, and access to adjacent properties.

### 7.6.2. Georgia Roundabouts Design Considerations

This policy is for the purpose of facilitating the selection of roundabouts on state facilities, and is not meant to be a design guide. The Georgia Department of Transportation does not have roundabout design guidelines. The information regarding modern roundabout design contained in the Federal Highway Administration's Roundabouts: An Informational Guide should be consulted.

### 7.6.3. Georgia Roundabouts Approval Process

Proposed concepts for installation of new roundabouts, or retrofit of existing intersections with roundabouts, must be approved by the State Traffic Engineer. The concept report should include an existing conditions sketch, preliminary design sketch, traffic counts, turning movement counts, capacity analysis, and crash data.

## 7.7. Highway-Railroad Grade Crossings

When a Highway- Railroad grade crossing is included on a project, designers should coordinate with the GDOT Railroad Crossing Manager, Railroad Crossing Improvement Unit<sup>5</sup>, in conjunction with concept development for a transportation improvement project.

The designer should be familiar with most current versions of the following resources:

- AASHTO *A Policy on the Geometric Design of Highways and Streets (Green Book)*, Chapter 9. Intersections
- American Railway Engineering and Maintenance of Way Association (AREMA) specifications (visit [www.arema.org](http://www.arema.org) for additional information)
- railway company regulations
- GDOT Standard Drawing and Specifications
- FHWA *Manual on Uniform Traffic Control Devices (MUTCD)*

A highway-railroad crossing involves either a separation of grades or a crossing at-grade. GDOT strongly encourages consideration of grade separated highway-railroad crossings. However, topographical and/or right-of-way limitations may make at-grade crossings the more feasible option.

When an at-grade, highway-railroad crossing is included in the design of a roadway construction/reconstruction project, train-activated warning devices (i.e. gates, lights, and bells) shall be included in the design. Train-activated warning devices provide drivers with a positive indication of the presence or the approach of a train at the crossing.

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<sup>7</sup> The Railroad Crossing Improvement Office (see <http://www.dot.state.ga.us/dot/operations/traffic-safety-design/subunit/rrcross.shtml>) is a unit of the GDOT Office of Traffic Safety and Design (home page: <http://www.dot.state.ga.us/dot/operations/traffic-safety-design/index.shtml>).

The geometric design of a highway-railroad grade crossing involves the elements of alignment, profile, sight distance, and cross section. The roadway should cross the railroad at- or nearly at- a right angle. The roadway gradient should be flat at- and adjacent to- the railroad crossing to permit vehicles to stop, when necessary, and then proceed across the tracks without difficulty. The vehicle operator can observe an approaching train and bring the vehicle to a stop prior to encroaching into the crossing area. Also the roadway width at all crossings should be the same as the roadway width approaching the crossing.

### **7.7.1. Horizontal Alignment**

As per the AASHTO *Green Book* (2004), to the extent practical:

- The highway should be designed to intersect the railroad tracks at a right angle.
- There should be no intersections or driveways, and in areas where a highway intersection is close to a railroad crossing, sufficient distance between the tracks and the highway intersections should be provided to enable highway traffic in all directions to move expeditiously. Where adequate storage distance between the main track and a highway intersection is not available, interconnection of the highway traffic signals with the train-activated warning devices and appropriate signage and pavement markings is strongly recommended.
- Placement of crossings on highway or railroad curves should be avoided because a roadway curvature can inhibit a driver's view of the crossing ahead, a railroad curvature may inhibit a driver's view down the tracks from both a stopped position at the crossing and on the approach to the crossing, and crossings located on both highway and railroad curves present maintenance problems and poor rideability for highway traffic due to conflicting superelevations.

### **7.7.2. Vertical Alignment**

As per the AASHTO *Green Book* (2004), to the extent practical:

- Highway and railroad intersections should be level:

The crossing surface should be at the same plane as the top of the rails for a distance of 2-ft. outside the rails. This is done to prevent low clearance vehicles from becoming caught on the railroad tracks.

The surface of the highway should not be more than three inches higher or lower than the top of the nearest rail at a point 30-ft. from the rail, unless track superelevation makes a different level appropriate.

If a roadway approach section is not level, or if the rails are superelevated, adequate rail clearances should be determined through a site-specific analysis.

- Vertical curves should be of sufficient length to ensure an adequate view of the crossing.
- Vertical curves should be used to traverse from the highway grade to a level plane at the elevation of the rails.

### 7.7.3. Highway-Rail Grade Traffic Control Considerations

Highway-rail grade crossing traffic control considerations are discussed in detail in the FHWA publication, *Guidance on Traffic Control Devices at Highway-Rail Grade Crossings*<sup>6</sup>. The following discussion summarizes the key points of this FHWA publication.

At a highway-rail grade crossing, the train always has the right of way. The process for determining the types of highway traffic control device(s) that are needed at a highway-rail grade crossing, or if a highway-rail crossing should exist, involves two-steps:

- Required Information - identifying what information the vehicle driver needs to be able to cross safely
- System operating characteristics - determining if the resulting driver response to a traffic control device is “compatible” with the intended system operating characteristics of the highway and the railroad facility.

#### Required Information

The first step involves three essential elements required for ‘safe’ passage through an at-grade crossing, which are incidentally the same elements a driver needs for crossing a highway-highway intersection:

- **Advance notice / stopping sight distance** – this element involves the drivers’ ability to see a train and/or the traffic control device at the crossing ahead to bring the vehicle to a stop at least 15-ft. short of the near rail.
- **Traffic control device comprehension** – this element is a function of the types of traffic control devices at the highway-rail crossing. According to FHWA, “there are typically three types of control devices, each requiring a distinct compliance response per the Uniform Vehicle Code, various Model Traffic Ordinances, and state regulations” (2002). These three types of control devices are: crossbuck, operating flashing lights that have the same function as a STOP sign, and flashing lights with lowered gates that have the same function as a red vehicular traffic signal.
- **Driver decision to proceed through the grade crossing** - this element concerns the driver’s decision to safely proceed through the grade crossing. It involves sight distance available both on the approach and at the crossing itself.

#### System Operating Characteristics

The second step involves a traffic control device selection process considering respective highway and rail system operational requirements. Within these contexts, FHWA notes the following operation and safety variables that should be considered (2002):

- highway - AADT (Annual Average Daily Traffic), legal and/or operating speed

<sup>6</sup> FHWA. *Guidance on Traffic Control Devices at Highway-Rail Grade Crossings*. 2002

The 2002 version of this publication is available online at: <http://safety.fhwa.dot.gov/media/twgreport.htm>

- railroad - train frequency, speed and type (passenger, freight, other)
- highway - functional classification and/or design level of service
- railroad - FRA class of track and/or high speed rail corridors
- proximity to other intersections
- proximity to schools, industrial plants, and commercial areas
- proximity to rail yards, terminals, passing tracks, and switching operations
- available clearing and corner sight distance
- prior accident history and predicted accident history
- proximity and availability of alternate routes and/or crossing
- other geometric conditions

“Special consideration should also be given to situations where highway-rail crossings are sufficiently close to other highway intersections that traffic waiting to clear the adjacent highway intersection can queue on or across the tracks, and when there are two or more sets of tracks sufficiently close to each other that traffic stopped on one set could result in a queue of traffic across the other” (FHWA, 2002).

### **Highway Operational Requirements**

FHWA describes the following with respect to highway operational requirements of highway-rail grade crossings (2002):

- Passive highway-rail grade crossings with a restricted sight distance require an engineering study to determine the safe approach speed based upon available stopping and/or corner sight distance.
- As a minimum, an advisory speed posting may be appropriate, or a reduced regulatory speed limit might be warranted.
- Active devices improve highway capacity and level of service near a crossing, particularly where corner sight distances are restricted; however, the effects of such a stop delay will increase as traffic volumes increase which will result in vehicle delay increases.

The type of control installed at highway-rail crossings should be evaluated in the context of the highway system classification and level of service.

### **Railroad Operational Requirements**

“Function, Geometric Design, and Traffic Control - Functional classification is important to both the highway agency and railroad operator. Where the highway intersects a railroad, the crossing, whether grade separated or at-grade, should be designed consistently with the functional classification of the highway or street. These design considerations can also extend to traffic control” (FHWA, 2002).

#### **7.7.4. Traffic Control Devices**

The purpose of traffic control at highway-rail grade crossings is to permit safe and efficient operation of both vehicle and train traffic over such crossings. Highway vehicles approaching a

highway-rail grade crossing should be prepared to yield and stop, if necessary, if a train is at or approaching the crossing.

Refer to the current FHWA *Guidance on Traffic Control Devices at Highway-Rail Grade Crossings* and the current FHWA *MUTCD* for additional information relating to the following types of highway-rail grade crossing traffic control devices:

- **Passive Devices** - all highway-rail crossings having signs and pavement markings (if appropriate to the roadway surface) as traffic control devices that are not activated by trains. Passive highway-rail crossing devices include: highway-rail grade crossing (crossbuck) signs, STOP signs, and YIELD signs.
- **Active Devices** - all highway-rail grade crossings equipped with warning and/or traffic control devices that gives warning of the approach or presence of a train. Active devices are generally categorized as standard active devices (i.e. flashing-light signals, cantilever flashing-light signals, and automatic gates) and supplemental active devices (i.e. active warning signs with flashers, or active turn restriction signs).
- **Median Separation** - the numbers of crossing gate violations can be reduced by restricting driver access to the opposing lanes. The use of median separation devices have resulted in a significant reduction in the number of vehicle violations at crossing gates. Other positive-barrier devices that can be used to prohibit crossing gate violations include: barrier walls, wide raised medians, non-mountable curb islands, mountable raised curb systems, four-quadrant traffic gate systems, and vehicle arresting barrier system - barrier gates.
- **Train Detection Systems** - Joint study and evaluation is needed between the highway agency and the railroad to make a proper selection of the appropriate train detection system. Refer to the current FHWA *Guidance on Traffic Control Devices at Highway-Rail Grade Crossings* for additional information relating to issues specific to train detection systems, such as warning time, system credibility, various types of detection systems, as well as railroad train detection time and approach length calculations.

#### 7.7.5. Alternatives to Maintaining the Crossing

Refer to the current FHWA publication, *Guidance on Traffic Control Devices at Highway-Rail Grade Crossings*, for additional information on the following alternatives to maintaining a highway-rail grade crossing:

- **Crossing Closure** – “The crossing closure decision should be based on economics; comparing the cost of retaining the crossing (maintenance, crashes, and cost to improve the crossing to an acceptable level if it would remain, etc.) against the cost (if any) of providing alternate access and any adverse travel costs incurred by users having to cross at some other location. Because this can be a local political and emotional issue, the economics of the situation cannot be ignored” (FHWA, 2002). FHWA recommends two documents that provide guidance with regard to political, emotional, and economic ramifications of closing an at-grade highway-railroad crossing: a joint FRA/FHWA publication entitled *Highway-Railroad Grade Crossings: A Guide to Crossing Consolidation and Closure* (1994), and a March 1995 AASHTO publication, *Highway-Rail Crossing Elimination and Consolidation*.
- **Grade Separation** – FHWA notes that the decision to grade separate a highway-rail crossing should be based on long term, fully allocated life cycle costs, including both highway and railroad user costs, rather than on initial construction costs (2002). A 1999 Texas Transportation Institute report entitled *Grade Separations-When Do We Separate?* provides a stepwise procedure for evaluating the grade separation decision and also describes a rough

screening method based on train and roadway vehicular volumes. Evaluation of the feasibility of highway-rail grade separation should consider many factors, including but not limited to:

- eliminating train/vehicle collisions (including the resultant property damage and medical costs, and liability)
- savings in highway-rail grade crossing surface and crossing signal installation and maintenance costs
- driver delay cost savings
- costs associated with providing increased highway storage capacity (to accommodate traffic backed up by a train)
- fuel and pollution mitigation cost savings (from idling queued vehicles)
- effects of any “spillover” congestion on the rest of the roadway system
- the benefits of improved emergency access
- the potential for closing one or more additional adjacent crossings
- possible train derailment costs

#### **7.7.6. Crossing Consolidation and New Crossings**

##### **Crossing Consolidation**

Guidelines for crossing consolidation can be found in publications such as:

- FRA/FHWA. *Highway-Railroad Grade Crossings, a Guide to Crossing Consolidation and Closure*. Federal Railroad Administration/Federal Highway Administration. 1994.
- FRA/FHWA. *Highway-Rail Crossing Elimination and Consolidation, A Public Safety Initiative*. National Conference of State Railway Officials. March 1995.

Furthermore, GDOT, road authorities, or local governments may choose to develop their own criteria for closures based on local conditions. The FRA and FHWA strongly encourage the use of specific criteria or an approach to consolidating railroad crossings, so as to avoid arbitrarily selecting a crossing for closure.

##### **New Crossings**

Similar to crossing closure/consolidation, consideration of opening a new public highway-rail crossing should likewise consider public necessity, convenience, safety, and economics. Generally, new grade crossings, particularly on mainline tracks, should not be permitted unless no other viable alternatives exist and, even in those instances, consideration should be given to closing one or more existing crossings to offset the additional risks associated with creating an additional crossing. If a new grade crossing is to provide access to any land development, the selection of traffic control devices to be installed at the proposed crossing should be based on the projected needs of the fully completed development. Communities, developers, and highway transportation planners need to be mindful that once a highway-rail grade crossing is established, drivers can develop a low tolerance for the crossing being blocked by a train for an extended period of time. If a new access is proposed to cross a railroad where railroad operation requires temporarily holding trains, only grade separation should be considered.

(FRA/FHWA, 2002)

### 7.7.7. GDOT At-Grade Highway-Rail Crossing Evaluation Criteria

#### Peabody-Dimmick Formula

The Peabody-Dimmick empirical method should be used to evaluate and establish an unadjusted “hazard index” for at-grade highway-railroad crossings. The Peabody-Dimmick Formula (often referred to as the Bureau of Public Roads Formula) is used to determine the expected number of train-vehicle crashes in five years. The formula is:

$$A_5 = 1.28 * ((V^{0.170} * T^{0.151}) / P^{0.171}) + K$$

Where:  $A_5$  = Expected number of train-vehicle crashes in five years (Unadjusted Hazard Index Rating, as it is not adjusted for school buses)

$V$  = Annual Average Daily Traffic (AADT)

$T$  = Average Daily Train Traffic

$P$  = At-grade Crossing Protection Coefficient

$K$  = Balancing factor used to offset variations in empirical data

Note: The hazard index only provides an initial approximation of the relative hazard rating of each crossing. While the Peabody-Dimmick formula takes into account the number of daily trains, the vehicular AADT, and a factor for the existing warning devices (protection coefficient); the designer must consider other factors that must be considered before reaching an Adjusted Hazard Index rating for a crossing. These factors include:

- visibility and sight distances
- speed (both train and vehicle)
- number of past train-vehicle crashes at the location
- number of tracks
- highway approach grades
- highway alignment
- number of highway approach lanes
- type of terrain
- nearby intersections
- condition of existing equipment

Based on site-specific information not included in the formula, GDOT’s current practice is that the Unadjusted Hazard Index rating produced by the Peabody-Dimmick Formula shall not account for more than 50% of the Adjusted Hazard Index rating.

#### Adjusted Hazard Index Rating

The Adjusted Hazard Index (AHI) Rating is the summation of the Unadjusted Hazard Index rating, the Adjustment Factor for School Buses, and the Adjustment for Train-Vehicle Crash history.

$$AHI = A_5 + S + A$$

Where:  $A_5$  = Unadjusted Hazard Index Rating

$S$  = Adjustment factor for School Buses

$A$  = Adjustment for train-vehicle crash history

### Adjustment Factor for School Buses

An adjustment factor should be added to the hazard index when a highway route intersects a railroad 'at-grade'. The adjustment factor, *S*, takes into account the number of school buses traversing the highway-rail crossing during a 24-hour period.

$$S = \frac{(4 * TPD + 8 * Buses) + 8}{10}$$

Where: *S* = Adjustment Factor for School Buses

*TPD* = Number of Trains per day

*Buses* = Number of Buses per day

Note: The adjustment factor for school buses shall only be applied to the Unadjusted Hazard Index rating for highway-rail grade crossings that utilize passive warning devices. If a highway-rail grade crossing utilizes train-activated warning devices, then *S* = 0.

### Adjustment Factor for Train-Vehicle Crash History

An adjustment factor should be added to the hazard index based on crash history at a highway-rail crossing. The adjustment factor, *A*, takes into account the number of fatalities, injuries, or property damage only cases when train-vehicle crashes occur.

$$A = 2 * F + 1 * I + 0.5 * PD$$

Where: *A* = Adjustment Factor for Accidents

*F* = A train-vehicle crash resulting in a fatality

*I* = A train-vehicle crash resulting in an injury

*PD* = A train-vehicle crash resulting in property damage only

Note: If a train-vehicle crash results in a fatality, the Adjustment Factor for the train-vehicle crash is 2. (It should be assumed that subject vehicle's occupants were injured and the vehicle involved in the incident was damaged).

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## Summary of Chapter 7 Revisions

### June 5, 2009 Revisions

7.2.3	Revised the Turn lanes section
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### May 21, 2009 Revisions

7.6	Revised the Roundabouts section.
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### February 12, 2009 Revisions

7.2.3	Revised the Design criteria for turn lanes.
7.2.3	Deleted the statement "at both public roads" because it is redundant with previous wording in this section.
7.3	Replaced the word "desirable" with "preferable" in the third bulleted statement.
7.6	Revised the entire Roundabout section
7.6.1	Revised the entire "Georgia Roundabouts Selection Guidelines".
7.6.2	Revised the entire "Roundabouts Design Considerations".
7.6.3	Revised the entire "Georgia Roundabouts Approval Process".
7.6.4	Deleted from the Manual.
7.7.5	Revised the word "can not" to "cannot"
Table 7.1	Deleted from the Manual.

### June 1, 2007 Revisions

7.3	Clarified language concerning median openings for commercial developments
	Clarified language concerning median opening spacing in urban areas